MULTILAYER STRUCTURE INCLUDING DIFFUSION BARRIER LAYER AND DEVICE INCLUDING THE MULTILAYER STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. §119 to Korean Patent Application No. 10-2015-0108864, filed on Jul. 31, 2015, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates to a diffusion barrier layer, a multilayer structure including the diffusion barrier layer, and/or a device including the multilayer structure.

[0004] 2. Description of the Related Art

[0005] In general, many electronic devices and semiconductor devices are manufactured by combining and connecting semiconductors, insulators, and conductors with one another. For example, various integrated circuits (ICs) are manufactured by forming a plurality of unit elements on a semiconductor substrate and repeatedly stacking insulating layers (interlayer insulating layers) and electrode lines on the plurality of unit elements.

[0006] However, when the electronic devices or the semiconductor devices are manufactured in this way or under operation, temperatures of constituent layers thereof may increase and an electrical stress may occur due to application of a voltage or current. Therefore, materials (atoms) diffuse between adjacent constituent layers, thus causing a degradation in the characteristics of the electronic devices or semiconductor devices and also a reduction in the reliability and durability thereof. As the degree of integration of the electronic devices or the semiconductor devices increases, it is more difficult to solve limitations caused by the diffusion of materials between constituent layers.

SUMMARY

[0007] Provided are diffusion barrier layers having excellent characteristics and/or multilayer structures including the diffusion barrier layers.

[0008] Provided are diffusion barrier layers including two-dimensional (2D) materials and/or multilayer structures including the diffusion barrier layers.

[0009] Provided are diffusion barrier layers which may be formed to have a very small thickness so as to be suitable for high-integration devices, and/or multilayer structures including the diffusion barrier layers.

[0010] Provided are devices including the diffusion barrier layers and/or the multilayer structures.

[0011] Provided are methods of forming the diffusion barrier layers and/or methods of manufacturing the devices.

[0012] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of example embodiments.

[0013] According to example embodiments, a multilayer structure includes a first material layer, a second material layer, and a diffusion barrier layer. The second material layer is connected to the first material layer and spaced apart from the first material layer. The diffusion barrier layer is between the first material layer and the second material layer. The diffusion barrier layer includes a non-graphene-based two-dimensional (2D) material.

[0014] In example embodiments, the 2D material may include a metal chalcogenide-based material having a 2D crystal structure.

[0015] In example embodiments, the metal chalcogenide-based material may include at least one metal element selected from the group consisting of molybdenum (Mo), tungsten (W), niobium (Nb), vanadium (V), tantalum (Ta), titanium (Ti), zirconium (Zr), hafnium (Hf), technetium (Tc), rhenium (Re), ruthenium (Ru), cobalt (Co), palladium (Pd), platinum (Pt), copper (Cu), gallium (Ga), indium (In), tin (Sn), germanium (Ge), and lead (Pb). The metal chalcogenide-based material may include at least one chalcogen element selected from the group consisting of sulfur (S), selenium (Se), tellurium (Te), and oxygen (O).

[0016] In example embodiments, the 2D material may include a transition metal dichalcogenide (TMDC).

[0017] In example embodiments, the 2D material may have a trigonal prismatic crystal structure or an octahedral crystal structure.

[0018] In example embodiments, the diffusion barrier layer may have a thickness of greater than 0 nm and less than or equal to about 10 nm.

[0019] In example embodiments, the diffusion barrier layer may have a thickness of greater than 0 nm and less than or equal to about 5 nm.

[0020] In example embodiments, the diffusion barrier layer may have a thickness of greater than 0 nm and less than or equal to about 3 nm.

[0021] In example embodiments, the diffusion barrier layer may have a resistivity of about 10^{-2} Ω·cm or less. For example, the diffusion barrier layer may have a resistivity of about 10^{-4} Ω·cm to about 10^{-2} Ω·cm.

[0022] In example embodiments, the diffusion barrier layer may be doped with a dopant.

[0023] In example embodiments, the first material layer may include an insulator, and the second material layer may include a conductor.

[0024] In example embodiments, the first material layer may include a semiconductor, and the second material layer may include a conductor.

[0025] In example embodiments, the multilayer structure may include a conductor, an understructure, and an insulating material on the understructure. The insulating material layer may define an opening. The diffusion barrier layer may cover the insulating material layer in the opening. The conductor may cover the diffusion barrier layer in the opening. The first material layer may include at least a part of one of the understructure and the insulating material. The second material layer may include at least a part of the conductor.

[0026] In example embodiments, the multilayer structure may further include an adhesion layer between the diffusion barrier layer and one of the first and second material layers.

[0027] In example embodiments, the adhesion layer may include at least one metal selected from the group consisting of molybdenum (Mo), tungsten (W), niobium (Nb), vanadium (V), tantalum (Ta), titanium (Ti), zirconium (Zr), hafnium (Hf), technetium (Tc), rhenium (Re), ruthenium